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Survey of Root and Foliar Fungal Diseases of Grown Tomato at Different Locations in Egypt

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Abstract* - The most reported areas for high production of tomato under open field and protected cultivation system in ARE were subjected to survey of either root or shoot systems fungal diseases at two growth stages of plant growth. Surveyed Tomato showing damping-off, root rot, wilt, early and late blights symptoms were subjected to isolation trails for the purpose of isolation the causal organisms. Rhizospheric samples of different healthy and diseased plants were collected at flowering growth stage from the same surveyed locations distributed for determining the frequency occurrence of different fungi associated with the root region of healthy and infected roots of tomato plants. The recorded diseases in surveyed locations were damping-off, root-rot, white rot, and wilt, early and late blights. The root fungal pathogens isolated from rhizospheric soil were Pythium spp., Fusarium spp. Rhizoctonia solani, Macrophomina sp. Sclerotium rolfsii which recorded in high frequency comparing with other microorganisms, T. harzianum, T. viride, T. hamatam, Aspergillus spp., Penicillium spp. as well as B. subtilis and P. fluorescens which isolated from Healthy plants. The genus Fusarium represented in highest records followed by the genus Rhizoctonia and Sclerotium respectively at all assayed samples. Meanwhile, the pathogens referred to genus Pythium, Macrophomina and Sclerotinia were represented in a lesser frequency.

Index Terms—**Plastic houses, root diseases, foliar diseases, tomato, soil rhizosphere.**

I. INTRODUCTION

Tomato plants (*Solanum lycopersicum* L.) considered one of the most important vegetable crops in Egypt and Tunisia as well as other countries in the world. Root rot disease caused *by Fusarium oxysporium*, *Rhizoctonia solani* Kuhu; *Fusarium solani* (Mart) Sacc. and *Sclerotium rolfsii* Sacc. are the most destructive disease of tomato [1,2]. Root and crown rot as well as wilt diseases of tomato caused by *Fusariun oxysporum f.sp. lyucopersci* and *F usarium oxysporun f sp radicis lycopersci* pathogens which survive in soil are responsible for serious losses in vegetables crop yield [3,4,5,6]. Moreover, Early and Late blights caused by *Alternaria solani* and *Phytophthora infestans* are the most important diseases attacking tomato plants under open field or plastic houses conditions [7,8,9,10]

Under plastic houses conditions tomato is reported to be infected with different root and foliar diseases, *i.e*. damping-off, root rot, white rot, wilt, early and Late blights as well as leaf spots [7,8,9,10,11,12,13,14]. The impact of plant pests on the aspiring producer of greenhouse vegetables is direct and significant. The prospective producer must understand that the greenhouse condition is a paradise for both the crop and the accompanying pests that afflict it. Plastic houses have led to changes in the microclimate of protected crops. Restricted air exchange results in the atmospheric humidity being much higher inside insulated greenhouses than conventional ones which encourage several plant diseases and cause physiological disorders. Climate change could alter stages and rates of development of the pathogen, modify host resistance, and result in changes in the physiology of host-pathogen interactions [15].

The aim of the present work was designed to monitor the diseases infection and associated rhizospheric microorganisms of tomato plants grown under open field or protected cultivation system at different Governmental locations throughout Egypt.

II. MATERIALS AND METHODS

Surveying of tomato fungal diseases throughout different open field and protected cultivation locations

The most reported areas for high production of vegetables under protected cultivation system in ARE were subjected to survey of either root or shoot systems diseases at two growth stages of plant growth, *i.e.* seedling (3-6 weeks after transplanting) and maturity (8-12 weeks after transplanting).

The percentage of different diseases incidence was recorded at different locations distributed in six governorates, *i.e*. Giza, Fayum, Kalubia, Ismaelia, Behiera and Minia. The average percentages of root and foliar diseases infections were calculated as the number of infected plants in relative to the total number of examined plants. Crop monitoring is the continually on-going surveillance to detect the presence of a disease at the very early stages of development, before economic damage has occurred. Therefore, the authors involved in working the crop monitoring are enough qualified of the common disease problems and what to look for to detect the presence of disease symptoms in certain crop.

Isolation, purification and identification of the diseases causal fungal pathogens

Samples of the diseased tomato plants were collected from different locations at governorates *i.e*. Giza, Fayum, Kalubia, Ismaelia, Behiera and Minia, at two growth stages of plant growth as mentioned above, were transferred to the laboratory of Plant Pathology Department, National Research Centre, Egypt. Collected root or shoot systems showing diseases symptoms were subjected to isolation trails for pathogenic fungi. Small pieces of infected roots or leaves of tomato were surface

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sterilized using sodium hypochlorite solution (3%) for 3 minutes, and washed with distilled sterilized water for several times. Then dried using sterilized filter paper and transferred into Petri-dishes containing potato dextrose agar medium (PDA). Plates were incubated at 25±2°C for 5-7 days for appearance fungal colonies. Hyphal tips of fungi were picked up and transferred to another PDA plates. Purified fungi were identified based on their microscopic and morphological characters according to [16,17,18].

Isolation different soil borne microorganisms, associated with healthy and infected tomato plants

Soil microorganisms, fungi and bacteria, associated with the root region of healthy and infected roots of Tomato plants were isolated following the method developed by [19] for studying the micro flora of the root region. The plate count technique according to [20] was followed for both total fungal and bacterial counts. Rhizospheric samples of different healthy and diseased plants were collected at flowering growth stage from the same surveyed locations distributed in six governorates as previously mentioned. The frequency occurrence of different fungi in assayed rhizospheric soil samples were recorded. The total bacterial count and common bacterial groups was also determined using dilution method. Identification of common bacterial groups was made according to cultural and morphological characters according to [21].

Statistical Analysis

All experiments were set up in a complete randomized design. One-way ANOVA was used to analyze differences between applied treatments. A general linear model option of the analysis system SAS [24] was used to perform the ANOVA. Duncan's multiple range test at P ≤ 0.05 level was used for means separation [25].

III. RESULTS AND DISCUSSION

Surveying of tomato fungal diseases throughout different open field and protected cultivation locations

Results of surveyed Tomato plants grown under open field and protected cultivation locations in different governorates in Egypt for diseases incidence are shown in Table (1 and) and figure (1 and 2). The recorded diseases were damping-off, root-rot, wilt, early & late blights and leaf spots. Under open field conditions, the obtained results in Table (1) revealed that the surveyed plants at early stages (3-6 weeks after transplanting) showed root infections expressed at highest records with root-rot infection followed by wilt and damping-off. The foliar infection showed similar trend as early blight followed by late blight and leaf spot, respectively. These records going up with the increasing of plant age to reach their maximum at 8-12 weeks (Fig. 1). It is interesting to note that, damping-off infections was not observed at the late growth stage of surveyed plants (Fig. 1).

Table (1) Survey of soil borne and foliar diseases of tomato plants grown under open field at different locations at six Governorates after (3-6 weeks) after transplanting

Governorate (Location)	Cultivar Variety (cvs.)	Diseases infection %					
		Damping-off	Root rot	wilt	Early blight	Late blight	Leaf spot
Giza	Peto-86	4.4d	11.4f	3.0d	9.0b	5.0c	4..0b
	Castel –rock	5.7c	14.2c	5.2b	6.2c	4.0d	3.0c
Kalubia	Peto-86	5.0c	18.0a	5.0b	12.0a	7.0a	5..0a
	Castel –rock	7.2a	17.2b	8.2a	9.2b	6.0b	4.0b
Behiera	Peto-86	2.2f	10.2g	1.0f	4.0e	2.4f	2.8d
	Castel –rock	5.2c	8.4h	2.2e	1.2h	2.8f	2.0d
Ismaelia	Peto-86	3.8e	10.8g	2.0e	6.0c	3.0e	4..0b
	Castel –rock	3.4e	13.2d	3.2d	4.4e	3.0e	3.0c
Fayum	Peto-86	1.4g	11.8f	2.0e	4.2e	3.4e	0.0f
	Castel –rock	6.2b	10.0g	3.2d	2.2g	4.0d	0.0f
Minia	Peto-86	3.1e	11.4f	2.2e	5.0d	3.0e	1.0e
	Castel –rock	2.0f	12.4e	4.2c	3.2f	3.0e	2.2d

Figures with the same letters in each column are not significantly differed (P≤0.05)

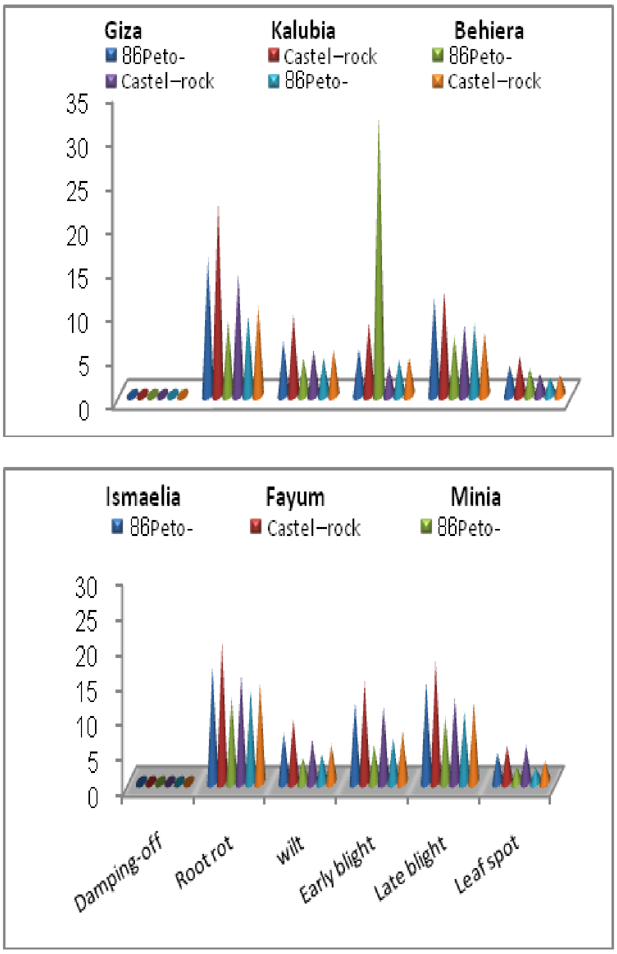

Fig. (1) Survey of soil borne and foliar diseases of tomato plants grown under open field at different locations at six Governorates after (8-12 weeks) after transplanting

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It is observed that (Table, 1 and Fig. 1) the recorded data indicate that all cultivars of various surveyed tomato plants grown under open field conditions are susceptible to disease infection with both soil borne and airborne plant pathogens at all surveyed locations. Furthermore, surveyed tomato plants at the two growth stages it was found that the recorded diseases infection damping-off, root rot, wilt, early and late blights diseases showed the highest records for the two cultivar varieties Peto-86 and Castel –rock at Kalubia Governorate, meanwhile the lowest diseases infections were recorded at Fayum Governorate. It was reported that Tomato plants are infected by several soilborne fungal pathogens such as *Fusarium* spp., *Rhizoctonia solani*, and *Sclerotium rolfsii* which cause serious diseases as root rots and wilt and finally reduced crop yield and quality [26,27]. Fusarium wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici* and *Rhizoctonia solani* causing damping off, cankers, root rots, fruit decay, foliage disease causes serious economic loss. *Fusarium oxysporum* penetrates the roots mainly through wounds and proceeds into and throughout the vascular system, leading to functional collapse, systemic wilting and often the death of the infected plant *Fusarium oxysporum* f. sp. *radicis-lycopersici* cause disease on hosts from several plant families, including tomato in the greenhouse [28]. Moreover, fungal phytopathogens are cause of many plant diseases and much loss of crop yields, especially in tropical and subtropical regions [*29*]. *Fusarium oxysporum* is major soilborne fungal pathogens of both greenhouse and field grown tomatoes in the warm vegetable growing areas of the world [30]. Also, *Fusarium* crown and root rot of tomato (FCRR) induced by *Fusarium oxysporum* Schlect f. sp. *radicis-lycopersici* Jarvis and Shomaker (FORL) is one of the most damaging soil-borne diseases of tomato causing heavy economic losses on plant grown in sterilized soils [31]. Furthermore, *Fusarium* crown and root rot of tomato (*Lycopersicon esculentum*) caused by *Fusarium oxysporum* f.sp. *radicis-lycopersici* (FORL) is a recent damaging disease of greenhouse crops in Tunisia [32]. On the other hand, early and late blights diseases were recorded to affect tomato plants grown either in the open fields or under protected cultivation system [33,34,35,36,37,38,39,40].

On the other hand, surveyed root and foliar diseases incidence of tomato plants grown under protected cultivation system are presented in Table (2) and Fig. (2). Presented data indicate that all cultivars of various surveyed tomato plants grown under protected cultivation system are also susceptible to disease infection with both soilborne and airborne plant pathogens at all surveyed locations. The recoded fungal diseases were damping-off, root rot, wilt, early and late blights diseases. It is observed that the recorded data indicate that two tomato cultivars Agyaat and Lora are susceptible to disease infection with both soil borne and airborne pathogens at all surveyed locations.

Table (2) Survey of soilborne and foliar diseases of tomato plants grown under protected cultivation system at different locations at four Governorates after (3-6 weeks) after transplanting

Governorate (Location)	Cultivar Variety (cvs.)	Diseases infection %					
		Damping-off	Root rot	wilt	Early blight	Late blight	Leaf spot
Minia	Agyaad	5.4f	7.8e	12.2e	12.0d	11.2a	3.4e
	Lora	6.4e	6.4f	11.0f	10.2e	8.2c	2.2f
Ismailia	Agyaad	10.2b	11.0c	18.2a	16.0b	8.8c	12.0a
	448	11.0a	12.0b	17.0b	22.2a	10.2b	8.8b
Behiera	Agyaad	8.8c	8.8d	14.2d	14.2c	10.2b	7.2c
	Lora	7.4d	13.8a	16.0c	10.0e	11.0a	5.2d
Giza (Dokki)	Agyaad	6.2e	7.4e	11.2f	8.2f	3.2e	0.0h
	Lora	5.2f	6.0f	9.4g	5.0h	4.0d	1.2g
Giza (Haram)	Agyaad	5.0f	7.0e	9.2g	7.2g	3.0e	0.0h
	Lora	4.4g	5.4g	8.8h	4.4i	4.0d	2.0f

Figures with the same letters in each column are not significantly differed (P≤0.05)

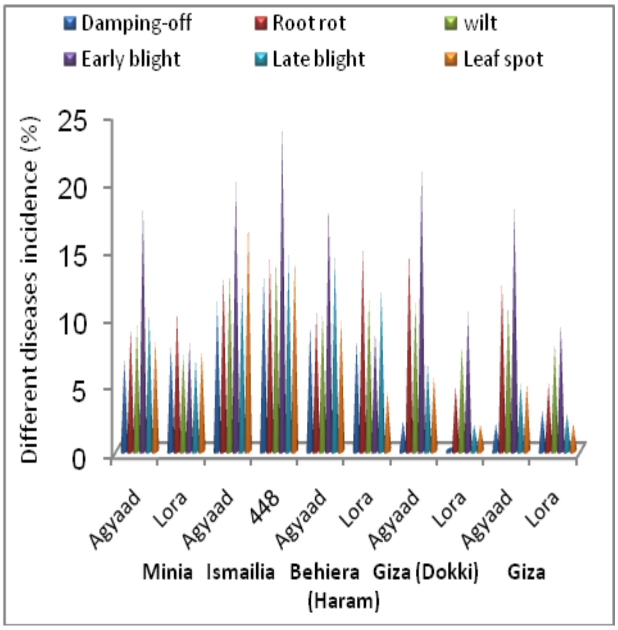

Fig. (2) Survey of soil borne and foliar diseases of tomato plants grown under protected cultivation system at different locations at four Governorates after (8-12 weeks) after transplanting

The highest percentages of fungal diseases were observed in Ismailia and Beheria followed by Minia Governorate. It is clear to note that early and late blight diseases followed by wilt and root rot diseases were recorded with highest percentage of incidence if compared with damping-off and leaf spot diseases.

Moreover, the major soil borne and foliar fungal diseases of tomato plants cvs. Agyaat and Lora grown under protected cultivation system at Dokki and El-Haram locations, Giza governorate showed that the most recorded fungal diseases were early and late blight

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followed by root rot and wilt diseases. Data also showed that the leaf spots disease had appeared in less percentage. Root rot diseases occurred with high percentages at the first stage of plants (3-6 weeks), meanwhile wilt and late blight disease (Fig. 2) occurred at the late stage of plant growth (8-12 weeks).

In this regard, it was recorded that the most important root diseases in greenhouses systems are caused by fungi of various species of Pythium and Phytophthora. These fungi are known collectively as water moulds and are important pathogens in soils in field [41]. Moreover, populations of fungi continue to build, and many are sustained throughout the year. With this mild climate comes the adaptability of both temperate and tropical pests, thus presenting a large number of potential problems for field crops [42]. These reports are in a harmony with the present results of our study. Surveyed production areas were examined for the initial symptoms of disease during routine crop maintenance activities, whereas, the earlier a disease is found and identified. The most recorded common diseases affecting greenhouse vegetables were also previously reported in Florida [43,44,45].

Isolation different soilborne microorganisms, associated with infected tomato plants

Rhizospheric samples of different healthy and diseased plants were collected at flowering growth stage from the same surveyed locations of six governorates as previously mentioned. The frequency occurrence of different fungi in assayed rhizospheric soil samples were recorded.

The obtained results showed the frequency occurrence of different fungi in assayed rhizospheric soil samples collected from grown tomato under open field (Table 3) and protected cultivation system (Fig. 3). The root fungal pathogens *e.g. Fusarium* spp. *Rhizoctonia solani*, *Macrophomina* sp., *Sclerothium rolfsii* were recorded in high frequency comparing with other fungal genera *Pythium* spp. and *Phytophthora* spp.

The genus *Fusarium* represented in highest records followed by the genus *Rhizoctonia* and *Sclerotium* respectively at all assayed samples. Meanwhile, the pathogens referred to genus *Pythium* and *Macrophomina* were represented in a lesser frequency.

It is clear to note that the highest recodes of soil borne fungi was observed in tomato cultivations at Giza and Kalubia followed by Behiera, Minia and Ismaelia Governorates. The obtained data interestingly indicate that the frequency occurrence of the root pathogens confirm the previously recorded data (Tables 1 and Fig. 1) concerning the percentages of root infection with damping-off, root rot and wilt diseases and could be considered as parallel decline shape. In this concern, the isolated fungi were previously recorded as the main causal of root diseases of such vegetables [46,47,48,49,50,51,52].

Table (3) Soil borne fungi isolated from tomato plants showing rot root and wilt diseases under open field conditions at different Governorates in Egypt

Governorate (Location)	Cultivar Variety (cvs.)	Isolated fungi(%)							
		F. oxysporun	*F. solani*	*R. solani*	*S. rolfsii*	*M. phaseolina*	*Pythium* spp.	*Phytophthora* spp.	Others
Giza	Peto-86	12.4 c	25.8 b	22.0 b	13.6 c	10.2 c	8.0 d	3.4 d	4.6 d
	Castel – rock	14.0 c	27.4 b	24.0 b	11.6 c	8.4 d	9.2 d	2.0 d	3.4 d
Kalubia	Peto-86	13.0 c	30.2 a	21.4 b	12.0 c	9.0 d	5.6 d	4.4 d	4.2 d
	Castel – rock	15.8 c	31.0 a	22.4 b	14.0 c	8.2 d	4.2 d	2.8 d	3.0 d
Behiera	Peto-86	8.2 d	20.0 b	18.4 c	15.0 c	15.2 c	8.0 d	7.2 d	8.0 d
	Castel – rock	10.4 c	21.0 b	21.2 b	18.2 c	15.0 c	6.4 d	5.0 d	2.8 d
Ismaelia	Peto-86	10.0 c	25.4 b	20.0 b	15.8 c	10.2 c	7.0 d	3.4 d	7.2 d
	Castel – rock	14.4 c	22.0 b	18.2 c	13.2 c	14.0 c	7.2 d	5.5 d	5.2 d
Fayum	Peto-86	7.4 d	25.2 b	16.4 c	12.8 c	16.0 c	10.0 c	5.2 d	7.0 d
	Castel – rock	8.0 d	24.0 b	20.0 b	14.0 c	17.0 c	8.0 d	5.2 d	4.4 d
Minia	Peto-86	10.0 c	25.2 b	15.0 c	14.4 c	18.0 c	5.4 d	5.0 d	7.0 d
	Castel – rock	11.4 c	21.0 b	13.4 c	20.2 b	16.4 c	8.0 d	6.0 d	4.0 d

Figures with the same letters in each column are not significantly differed ($P \leq 0.05$)

Isolation different soilborne microorganisms, associated with infected tomato plants

The isolated fungi and bacteria from the rhizospheric soil of tomato plants are recorded. Different fungi and bacteria isolated from tomato grown in open field are presented in Table (4), meanwhile the isolated microorganisms isolated from tomato grown under protected cultivation system are shown in Fig. (4). Results in Table (4) show that the major microorganisms isolated from healthy tomato roots collected from different open fields at different Governorates in Egypt were the fungi, *Trichoderma hamatam*, *T. harzianum*, *T. Viride*, *Penicillium* spp. and *Aspergillus* spp. as well as the bacteria *Bacillus subtilis* and *Psedomonas flouresences.* The highest percentage of occurrence of these microorganisms was observed in rhizosphere soil of tomato plants collected from Governorates Behiera, Minia and Ismaelia which recorded lower percentages of disease infections referring to Table (1). This observation is confirmed by reports about the soil borne antagonistic microorganisms, fungi and bacteria in cultivation soil.

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Trichoderma spp. are well documented as neffective biological control agents of plant diseases caused by soil borne fungi [53,54,55].

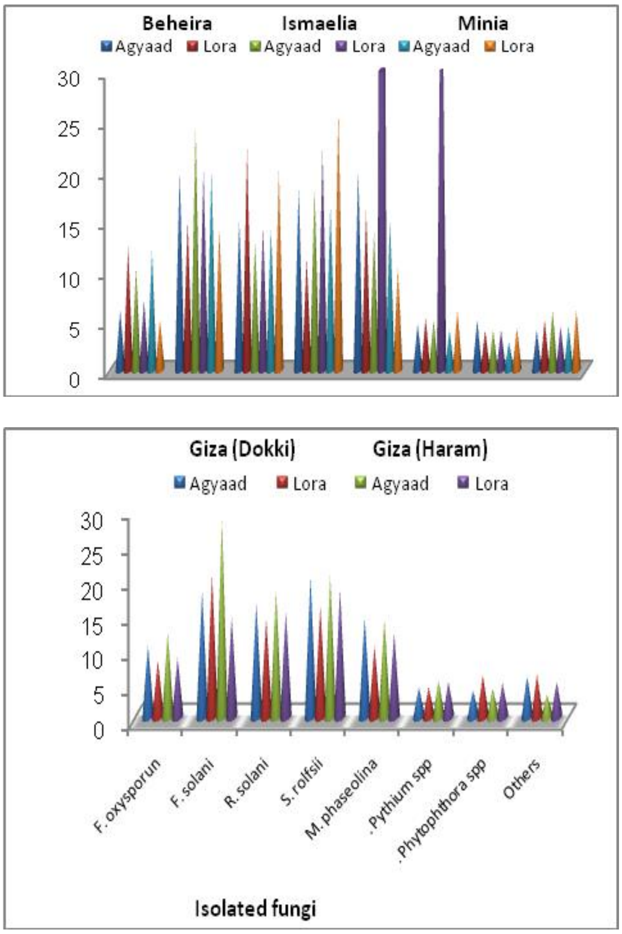

Fig. (3) Soil borne fungi isolated from tomato plants showing rot root and wilt diseases under protected cultivation system at different Governorates in Egypt

Also, [56,57,58] observed that the application of wheat bran colonized by *T. harzianum* to soil infested with *R. solani* and *S. rolfsii* reduced the incidence of root diseases caused by these pathogens in beans.

As for antagonistic bacteria, [59] found that seed treatment with *Bacillus* spp. actively controlled three fungal root diseases of wheat, and *Pseudomonas cepacia* or *P. fluorescens* applied to pea seeds acted as a biological control agent against Pythium damping-off and Aphanomyces root rot and was able to reduce disease incidence [60,61].

In addition, *Bacillus cereus* has proven to have beneficial effects on crop health including enhancement of soybean yield, suppression of damping-off of tomato [62] and alfalfa [63].

Extensive laboratory testing demonstrated a powerful suppression of damping-off of alfalfa by diverse strains of *B. cereus*, which confirmed preliminary testing under field conditions [63,64].

Table (4) Microorganisms isolated from the rhizosphere of healthy tomato collected plants grown in open fields at different Governorates in Egypt

Governorate (Location)	Cultivar Variety (cvs.)	Isolated fungi(%)							
		T. harzianum	*T. viride*	*T. hamatam*	*Penicillium spp.*	*Aspergillus spp.*	*B. subtilis*	*P. flourescens*	Others
Giza	Peto-86	4.4 c	2.8 c	8.0 c	17.6 b	12.2 b	18.0 b	13.4 b	4.6 c
	Castel – rock	4.0 c	0.0 d	11.0 b	18.6 b	18.4 b	15.2 b	2.0 c	3.4 c
Kalubia	Peto-86	11.0 b	10.2 b	14.4 b	12.0 b	9.0 c	18.6 b	6.4 c	4.2 c
	Castel – rock	8.8 c	3.0 c	6.4 c	14.0 b	18.2 b	14.2 b	4.8 c	3.0 c
Behiera	Peto-86	3.2 c	5.0 c	6.4 c	12.0 b	22.2 a	5.0 c	7.2 c	8.0 c
	Castel – rock	4.4 c	3.0 c	2.2 c	18.2 b	28.0 a	6.4 c	3.0 c	2.8 c
Ismaelia	Peto-86	4.0 c	2.4 c	2.0 c	20.8 a	18.2 b	2.0 c	1.4 c	7.2 c
	Castel – rock	2.4 c	5.0 c	6.2 c	13.2 b	20.0 a	3.2 c	1.0 c	5.2 c
Fayum	Peto-86	6.4 c	8.2 c	7.4 c	22.8 a	24.0 a	10.0 b	2.2 c	7.0 c
	Castel – rock	8.0 c	2.3 c	11.0 b	24.0 a	27.0 a	11.0 b	5.2 c	4.4 c
Minia	Peto-86	3.0 c	5.2 c	3.0 c	18.4 b	20.0 a	3.4 c	2.8 c	7.0 c
	Castel – rock	2.4 c	2.0 c	2.3 c	20.2 a	16.4 b	5.0 c	2.2 c	4.0 c

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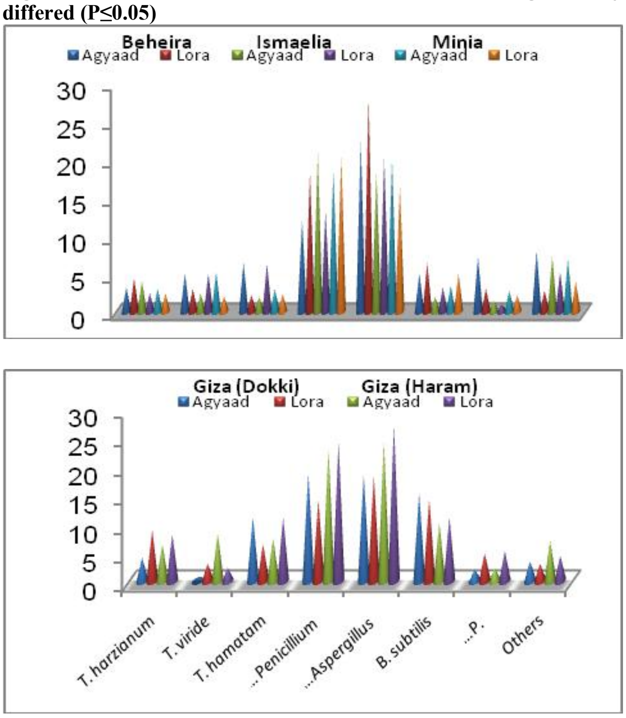

Fig. (4) Microorganisms isolated from the rhizosphere of healthy tomato collected plants grown in protected cultivation system at different Governorates in Egypt

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IV. CONCLUSION

Because plant population densities in cultivation soil are usually very high, some root rots foliar and other diseases can become severe very quickly. Use strict sanitation procedures for germinating seed and growing transplants. Diagnose all problems promptly. These include diseases, insect, nutritional, and growth problems. Promptly remove all diseased leaves, fruits, or entire plants to avoid spread of disease. These procedures are recommended for all growing vegetables and field crops to minimize the risk of introducing plant pathogens, reduce disease severity if pathogens are present, and to lessen dependency on labeled fungicides and nematicides. Pesticides, including biological control agents that may be commercially available in the future, must be used.

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